

Short Communications

An interactive program for digitization of seabed photographs (PHDIG)

T Ramprasad & R Sharma

National Institute of Oceanography, Dona Paula 403 004, Goa, India

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A program for digitization of seabed photographs to compute coverage and abundance of polymetallic nodules is developed. Since the objects in the seabed photograph are partially covered by thin sediment layer, the automatic scanning devices may yield erroneous results. In this method, the user has to define the outlines of the nodule images on the photograph. For estimation of coverage, the nodule outlines are assumed to be polygons. In order to avoid possible errors in the areal calculations, entire computational procedure is carried out in user coordinate system. The software can be used for any similar application with minor suitable modifications.

Seabed photographs are being extensively used for underwater investigations such as study of marine minerals, microrelief features and benthic organisms. This study deals with digitization of some of the measurable parameters of polymetallic nodules from the photographs such as coverage and nodule abundance.

The coverage can be calculated manually by graphical method, point counting¹ and visual estimation using cartoons². These methods are tedious and time consuming. A need for computer oriented approach is envisaged. Use of the graphic cell method is faster but accuracy may be compromised³. Estimation using electronic analyser is limited by its ability to discriminate between nodules and sediment⁴, hence visual evaluation is also necessary⁵.

To ensure that the nodule boundaries are properly defined, the program of photographic digitization (PHDIG) allows manual interaction through the digitizing table besides machine calculation. The program is coded in ANSI FORTRAN 77 and developed for host computer ND-520 and digitizer BENSON 6201. The program has been modified to suit the requirement of microcomputers having FORTRAN compilers. The program listing can be obtained on request from the authors.

Digitization of seabed photos involves computation of coverage and abundance of nodules. Coverage (C) refers to the area covered by nodules on the seabed (A_n), with respect to the entire area photographed on the seafloor (A_p):

$$C = (A_n / A_p) \times 100 \quad \dots (1)$$

The abundance (A) is measured in kg.m⁻² and calculated using the equation⁶.

$$A = (7.7 \times C \times D) / 100 \quad \dots (2)$$

where D = average nodule diameter (cm)

The area photographed on the seafloor (A_p) is calculated by initially defining its length and breadth along X and Y axes. Care is taken to reorient the photograph coordinates to avoid misalignment on the digitizer (Fig. 1) and origin is shifted to the left side bottom corner of the photograph. Each coordinate pair (x, y) from the digitizer is transferred into user coordinates by multiplying with the scale factor, which is ratio of the dimensions of the seafloor photographed to dimensions of the photograph read from the digitizer. The errors in digitization can occur due to the distortion in the medium (photograph) and the user's misalignment during digitization⁷.

In the digitization program, the outline of each nodule is considered to be a polygon and is divided into a number of triangles made from lines radiating

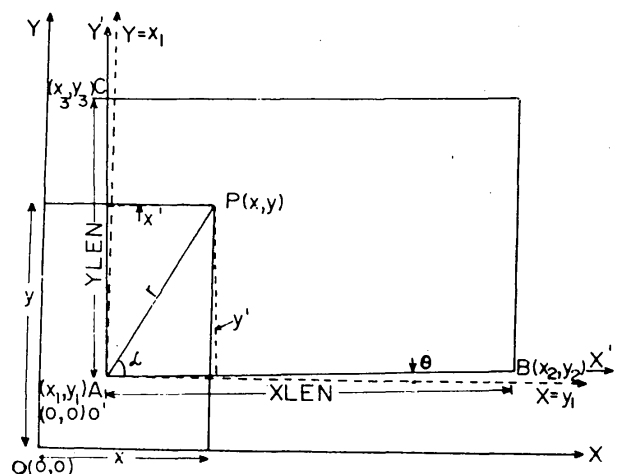


Fig. 1—Schematic diagram for correction of misalignment of the photograph

Table 1—Comparison of results obtained using PHDIG and graphical methods

Area photographed (cm ²)	Digitization method					
	PHDIG			Graphical		
	Area of nodules (cm ²)	Coverage (%)	Abundance (kg m ⁻²)	Area of nodules (cm ²)	Coverage (%)	Abundance (kg m ⁻²)
3337	409	12.25	5.77	434	13.00	6.22
7776	3727	47.93	16.60	3810	49.00	16.97

from a central point to the apexes on circumference (Fig. 2). For 'n' number of points on circumference, the area is given by following equation:

$$AN = \left(\sum_{i=2}^n \Delta_{1,i,i+1} \right) + \Delta_{1,n,2} \quad \dots (3)$$

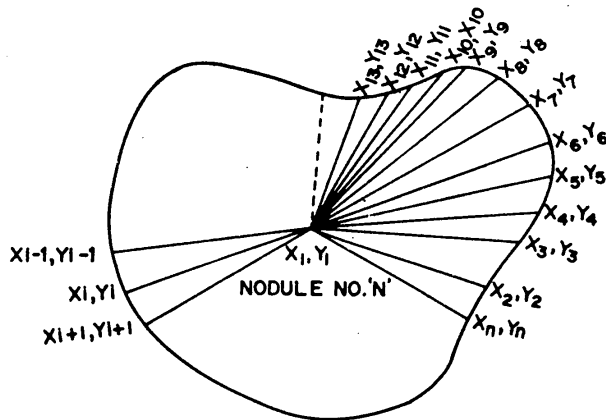
where AN = area of nodule 'N', Δ = area of triangle defined by corners at the suffix.

The area and the centroid of the polygon can be calculated from eigen values and eigen vectors of the mass matrix⁸ and also by characterising the polygons in terms of principal axes^{9,10}. However in this method, the centroid is not calculated as the objective is to calculate the area only. Total area covered by nodules on seabed (AN) is calculated by adding up individual areas of the nodules in the photograph, which is used for estimation of coverage and abundance. The procedure adopted for digitization is explained in a technical report¹¹. The photograph number, total area of nodules, area of the photograph, average diameter, coverage and abundance are stored in a write-append file.

Two photographs are digitized using the program and compared with the results obtained by manual (graphical) method (Table 1). In manual method, the grids on the graph partially covered by the nodules may also be counted as being completely covered, and hence yield higher values. By using PHDIG the dimensions of the polygonal sides are measured more accurately. Moreover other features observed in photographs like rock exposures and microrelief can also be analysed for their dimensions and coverage.

Minor modifications in this program enable digitization of peaks in X-ray diffractograms, areas of different grains (minerals, fossils, etc.) in photomicrographs and exposed features in sidescan sonar records. Manual interaction in marking the boundary enables accurate areal calculations. Better results can be expected by enlarging the photographs.

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$$\text{Area of Nodule 'N'} = \text{Area } \Delta(x_1, y_1), (x_2, y_2) \& (x_3, y_3) + \text{Area } \Delta(x_3, y_3), (x_1, y_1) \& (x_4, y_4) + \dots + \text{Area } \Delta(x_{i-1}, y_{i-1}), (x_1, y_1) \& (x_i, y_i) + \dots + \text{Area } \Delta(x_2, y_2), (x_1, y_1) \& (x_n, y_n)$$

Fig. 2—Schematic diagram for calculating the area of nodule outline by dividing into (n-1) triangles

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